# Acoustic-Trawl-Method Surveys

Estimating CPS biomasses, spatial and length distributions, natural mortalities, and their uncertainties

David A. Demer

Overview – ATM Sampling, Analyses, and Results

- ATM Sampling
  - Equipment
  - Sampling Design
  - Acoustic Sampling
  - Trawl Sampling
- ATM Analyses
  - Echo classification
  - Apportioning to Species
  - Converting to Fish Densities
  - Converting to Biomasses
  - Estimating Sampling Errors
- ATM Results
  - CPS Distributions and abundances
  - Length Distributions and Natural Mortalities
- Data management

- ATM Strengths
  - Direct estimates of CPS populations
  - Estimates for multiple species
- ATM Challenges
  - Sample Entire Stocks
  - Sample Near Shore
  - Sample Near Sea-Surface
  - Better Estimate Species Proportions & Sizes
- ATM Strategies for Improvement
  - Characterize Habitats for Multiple Stocks
  - Use Scanning, Multi-beam and Imaging Sonars
  - Characterize Trawl Performance
 - Sample Optically Underway

Equipment
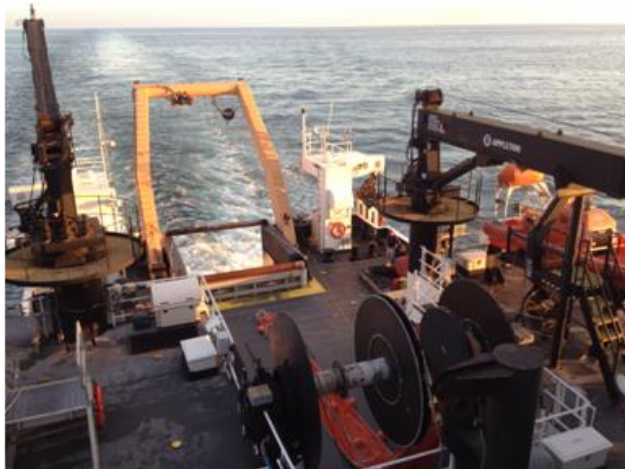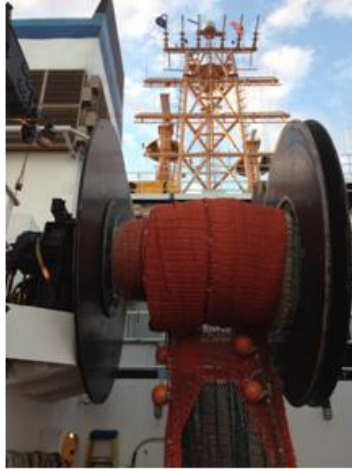
- Simrad EK60 Echosounders
- Nordic 264 Trawl

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Sampling Design

- Six Regional Fisheries
  - Ensenada, Mexico
  - San Pedro, California, USA
  - Monterey, California, USA
  - Oregon, USA
  - Washington, USA
  - Vancouver Island, Canada
- Seasonal Sardine Distribution
  - Spring – off central and so. CA
  - Summer – off central CA, OR, WA, and Vancouver Island

D.A. Demer and J.P. Zwolinski, in press, "Corroboration and refinement of a method to differentiate landings from two stocks of Pacific sardine (*Sardinops sagax*) in the California Current," *ICES Journal of Marine Science.*
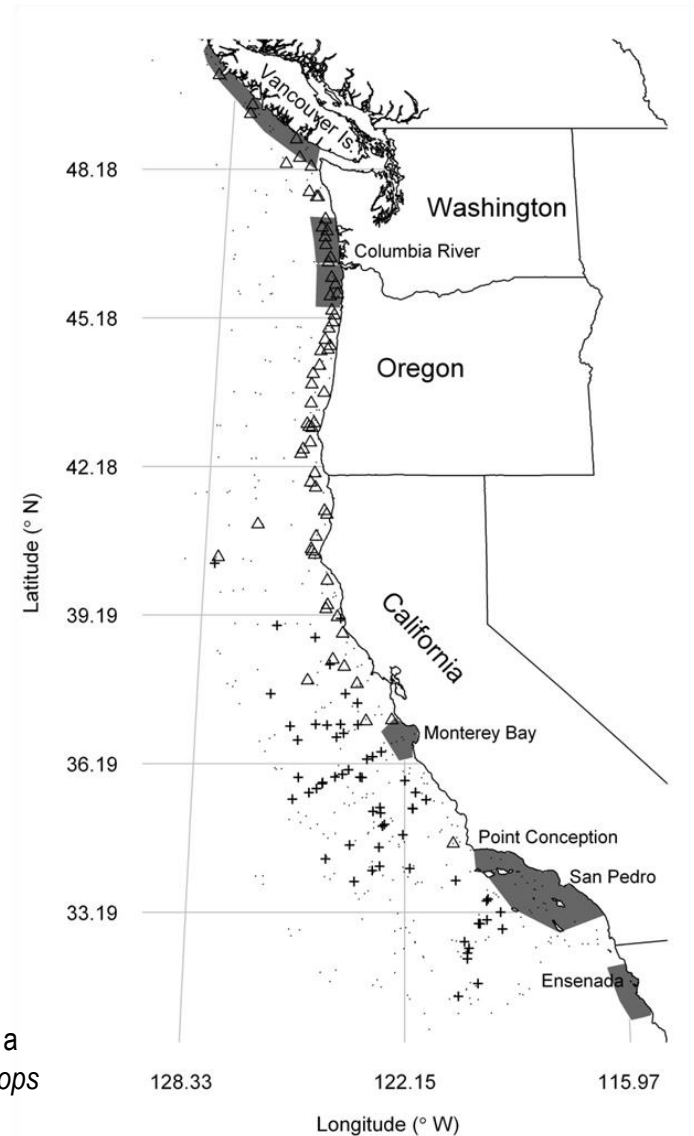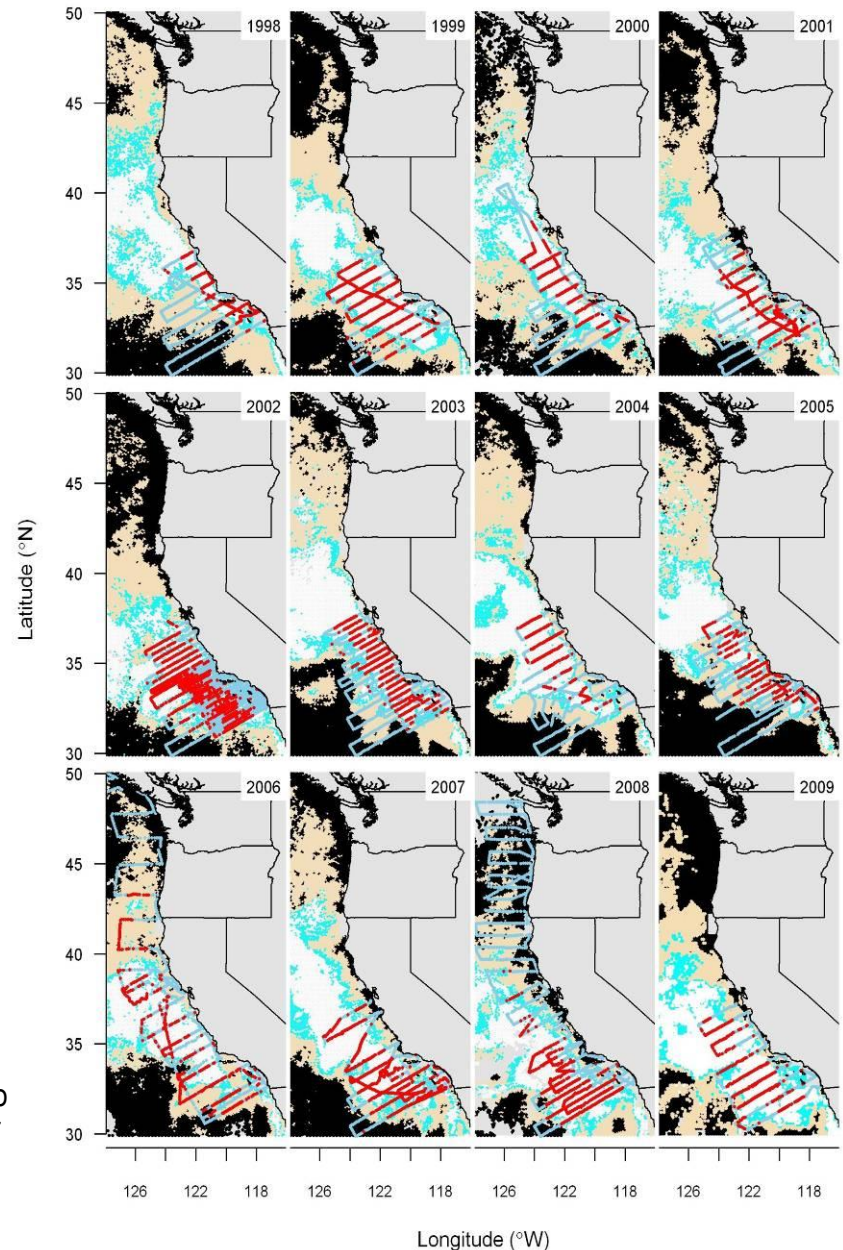
Sampling Design

- Potential habitat (optimal+good)
- Eggs (positive samples red)
- Positives contiguous
  - $11.5 \leq SST \leq 15.5$ °C &
  - $0.18 \leq CHL \leq 3.2$ mg/m^3
- Inshore boundary
  - Fresh upwelling
  - $SST < 11.5$ & $CHL > 3.2$
- Offshore boundary
  - Oceanic water
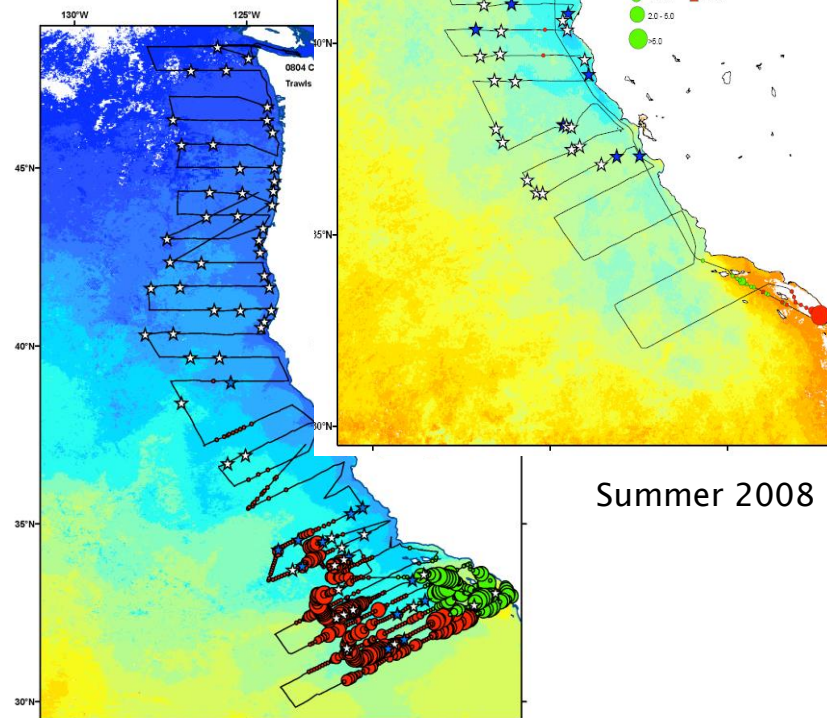 - $SST > 15.5$ & $CHL < 0.18$

J.P. Zwolinski, R.L. Emmett, and D.A. Demer, 2011, "Predicting habitat to optimize sampling of Pacific sardine (*Sardinops sagax*). *ICES Journal of Marine Science*, 68: 867–879.

Sampling Design

- ▢ -Optimal
- ▢ -Good
- ▢ -Bad
- ■ -Unsuitable
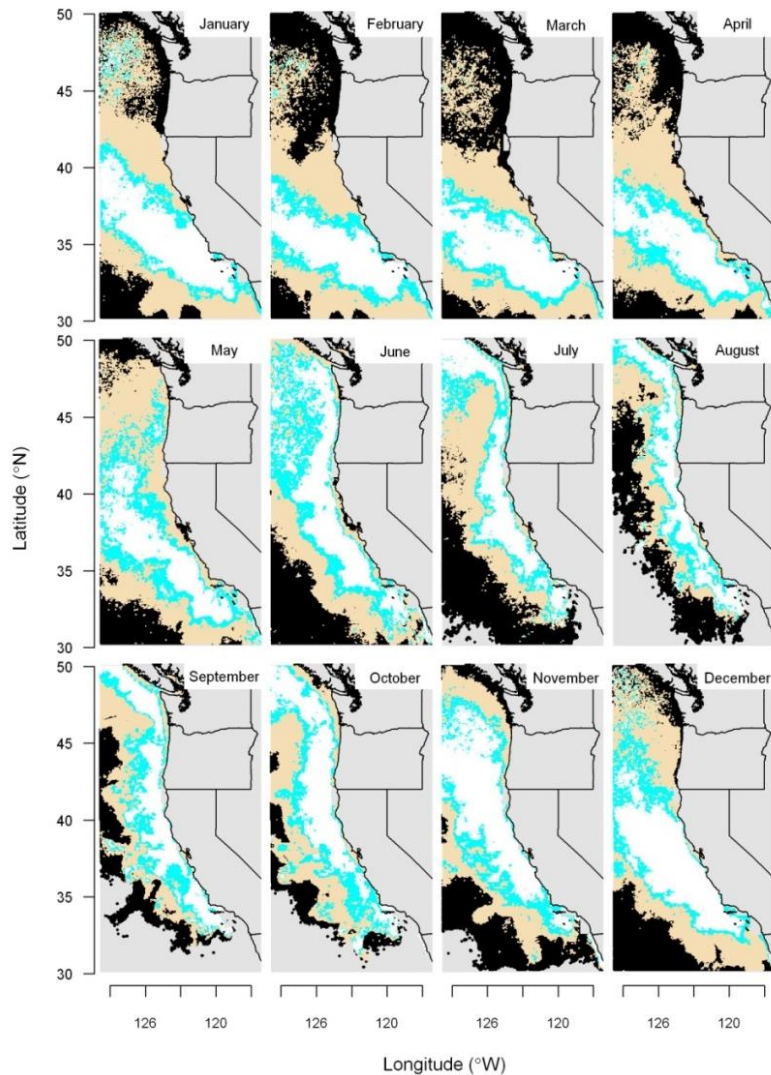
Spring 2008

Summer 2008

D.A. Demer, J.P. Zwolinski, K.A. Byers, G.R. Cutter, J.S. Renfree, T.S. Sessions, B.J. Macewicz, 2012, "Prediction and confirmation of seasonal migration of Pacific sardine (*Sardinops sagax*) in the California Current Ecosystem," *Fisheries Bulletin*, 110:52-70.
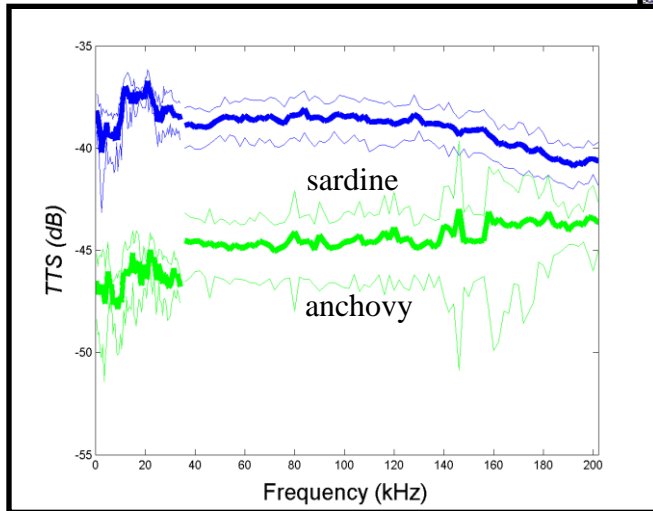
ATM Sampling

- Transects
    - 40 – 80 n.mi. spacing
    - Nominally 10 kt speed
    - Nighttime stations
- Acoustics
    - Simrad EK60s
    - 18, 38, 70, 120, 200 kHz
    - 1 ms pulses
    - Optimized range (to 750 m)
    - Optimized transmit interval
- Trawls
   - Nordic 264
    - Surface
    - Nighttime, nominally 3 day^{-1}
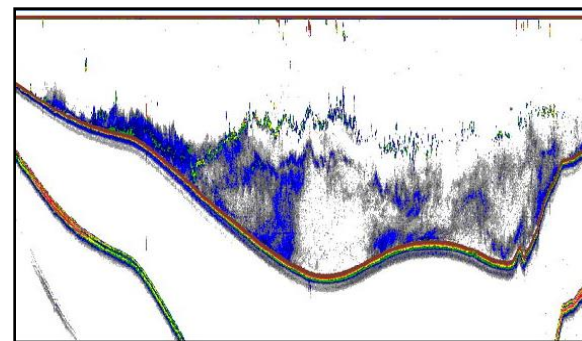
ATM Analysis – Echo Classification

'Noise reduced'

'Median filtered'

'CPS'

S.G. Conti and D.A. Demer, 2003, "Wide-bandwidth acoustical characterization of anchovy and sardine from reverberation measurements in an echoic tank," ICES J. Mar. Sci. 60:617-624.

D.A. Demer, G.R. Cutter, J.S. Renfree, and J.L. Butler, 2009, "A statistical-spectral method for echo classification". *ICES Journal of Marine Science*, 66: 1081–1090.
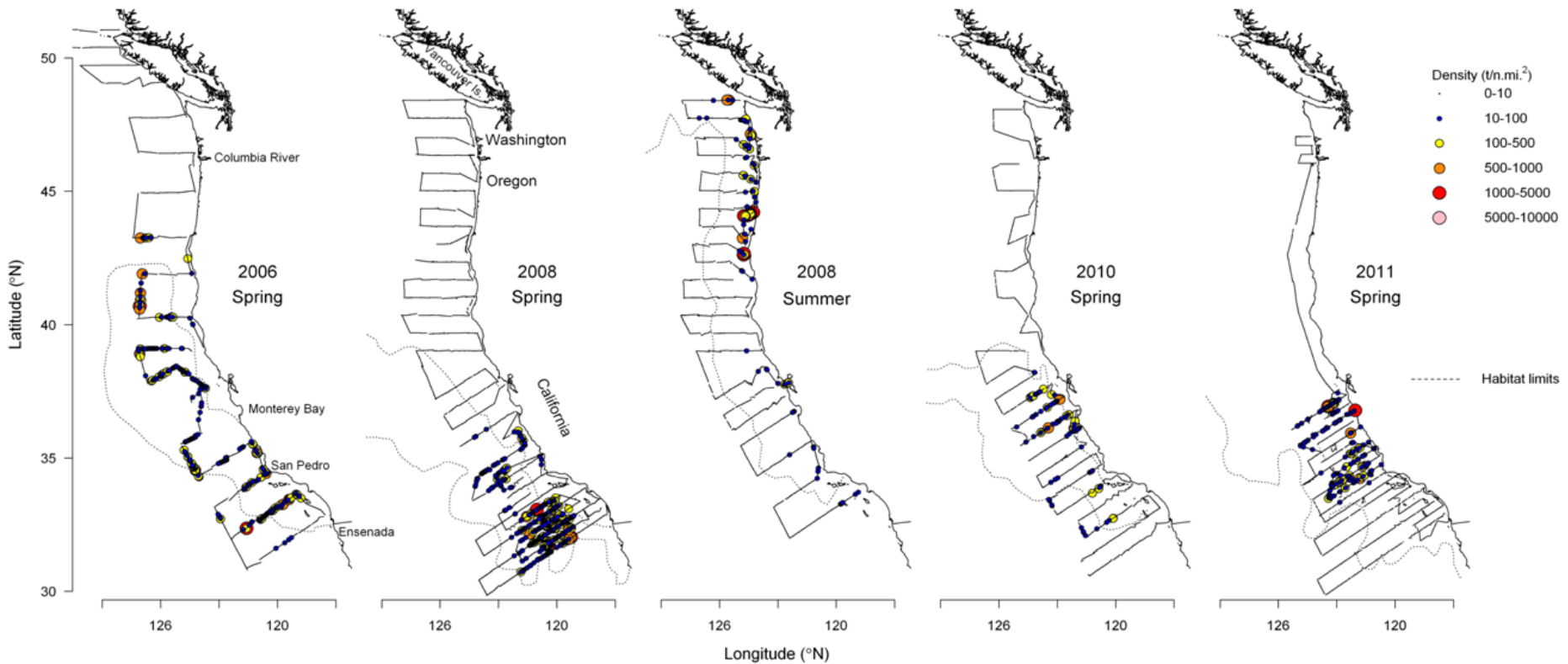
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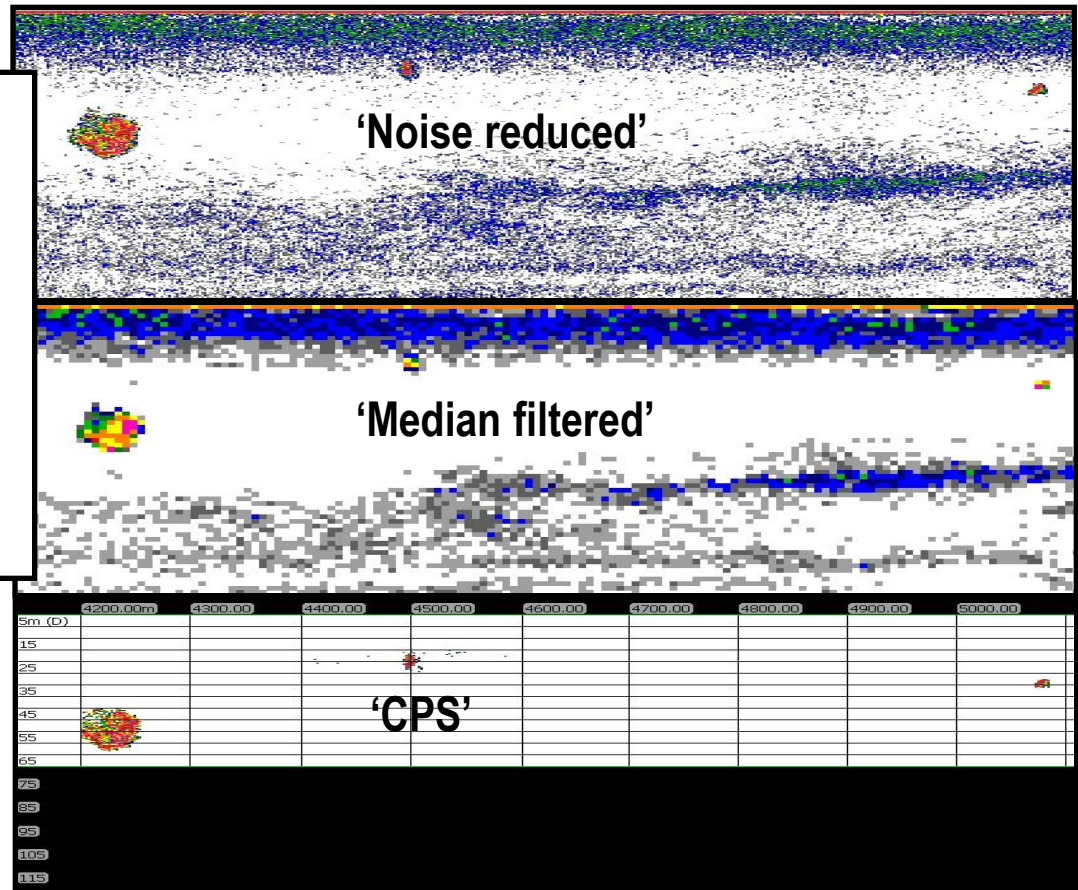
ATM Analysis – Apportioning to Species
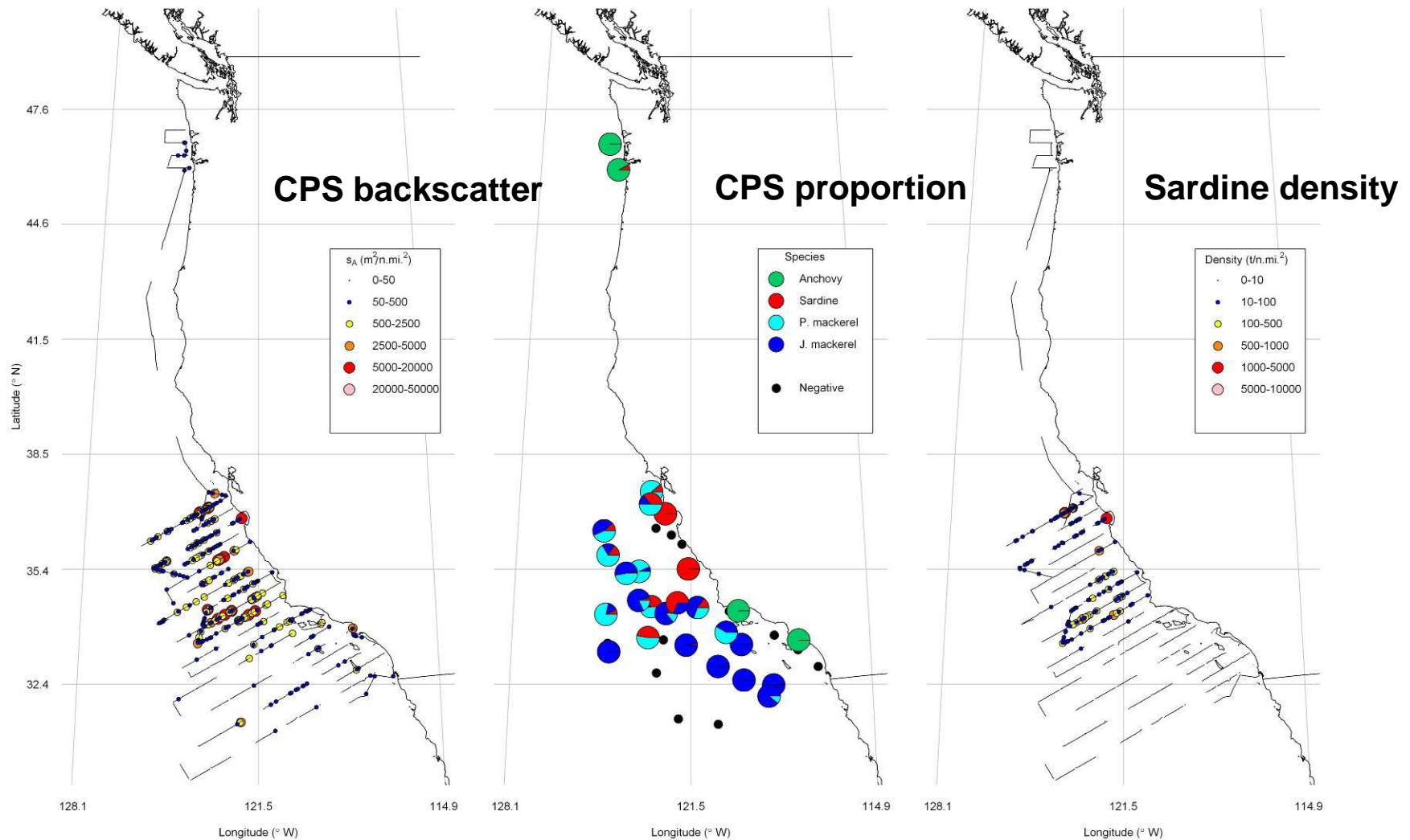
ATM Results – Estimated Distributions

J.P. Zwolinski, D.A. Demer, K.A. Byers, G.R. Cutter, J.S. Renfree, T.S. Sessions, and B.J. Macewicz, 2012, "Distributions and abundances of Pacific sardine (*Sardinops sagax*) and other pelagic fishes in the California Current Ecosystem during spring 2006, 2008, and 2010, estimated from acoustic—trawl surveys," *Fishery Bulletin* 110: 110-122.

ATM Results – Estimated Biomass and Error

• Biomass estimated by multiplying the stratum mean density and area

• Random sampling error estimated by bootstrap of transect mean densities

D.A. Demer, J.P. Zwolinski, G.R. Cutter, Jr, K.A. Byers, B.J. Macewicz, and K.T. Hill, in press, "Sampling selectivity in acoustic-trawl surveys of Pacific sardine (*Sardinops sagax*) biomass and length distribution," ICES Journal of Marine Science.
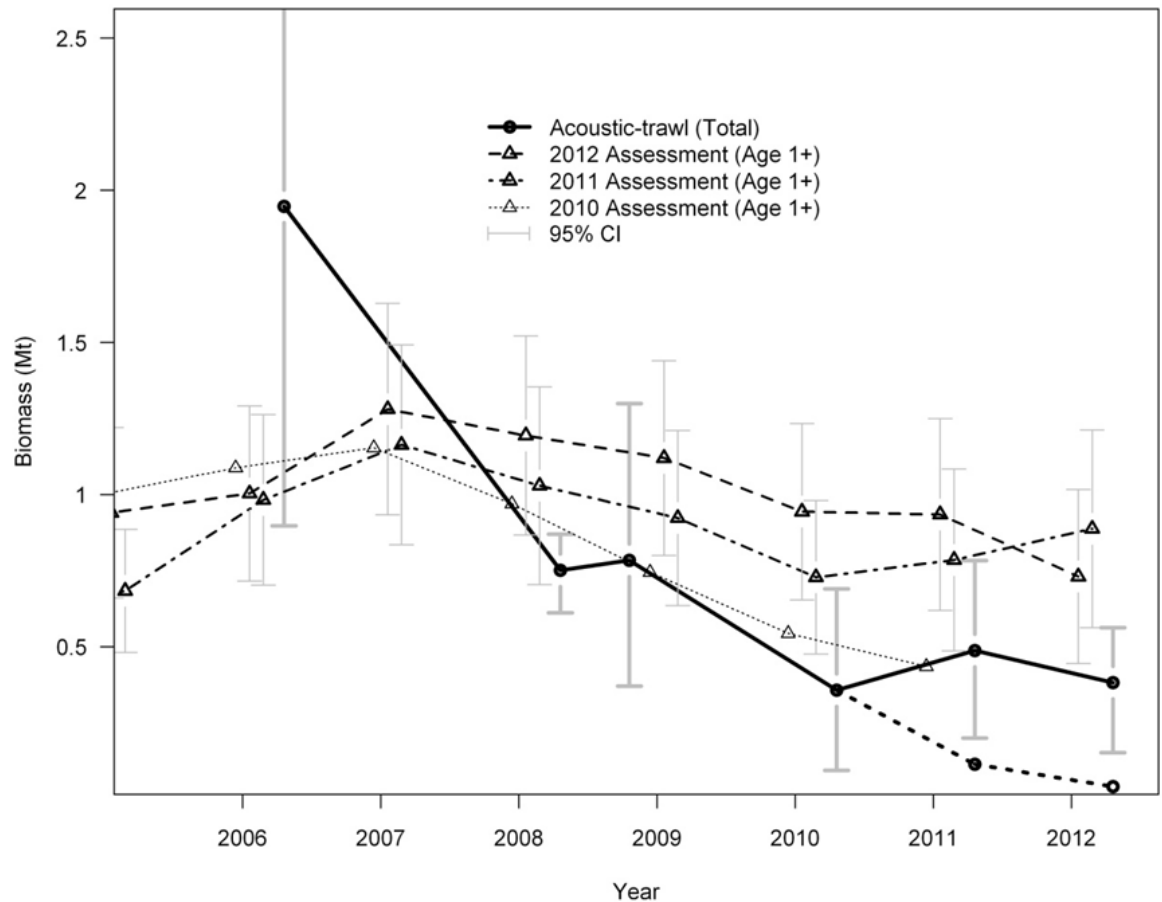
# ATM Results – Length Distributions

- Biomass-weighted lengths
- Observed cohorts
  - 2003-5 during 2006–2011
  - 2009-2010 during 2011–2012

D.A. Demer, J.P. Zwolinski, G.R. Cutter, Jr, K.A. Byers, B.J. Macewicz, and K.T. Hill, in press, "Sampling selectivity in acoustic-trawl surveys of Pacific sardine (*Sardinops sagax*) biomass and length distribution," ICES Journal of Marine Science.
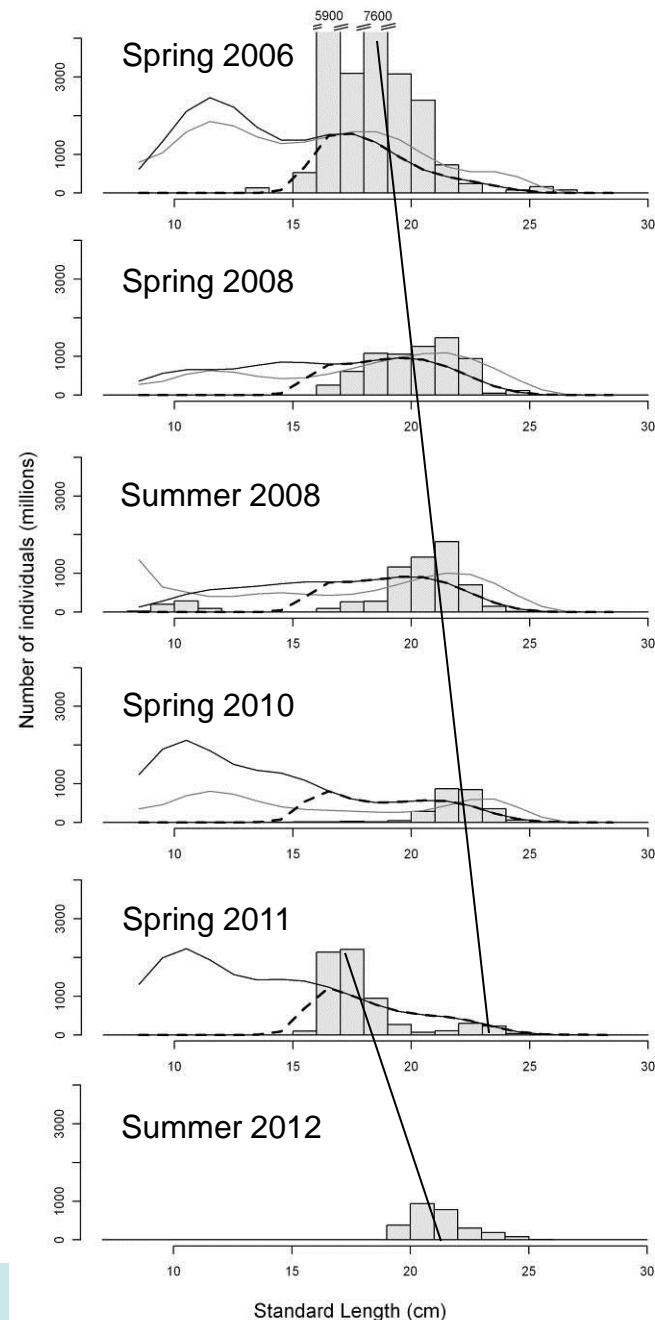
ATM Results – Natural Mortality
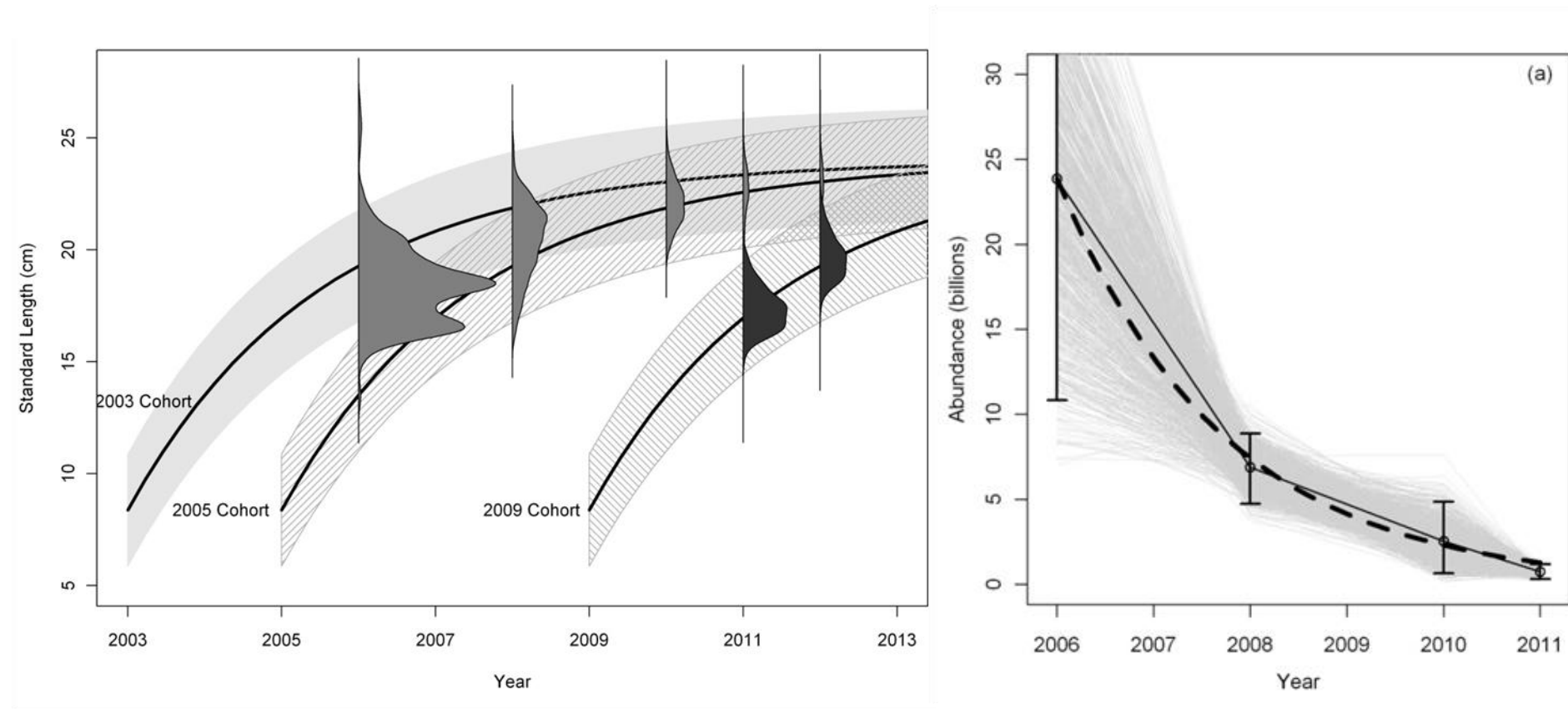
J.P. Zwolinski and D.A. Demer, in press, "Measurements of natural mortality for Pacific sardine (*Sardinops sagax*)," *ICES Journal of Marine Science*.

Data Management

- Data Processing and Telemetry
  - Data processed shipboard and ashore
  - Data and products telemetered via satellite
  - Reports drafted by the end of each survey
- Data Archive
  - Local data server
  - Managed by researchers
  - Backed-up by IT
- Publications
  - Peer-reviewed journals
  - NOAA Technical Memoranda

A statistical-spectral method for echo classification

David A. Demer, George R. Cutter, Josiah S. Renfree, and John L. Butler

Predicting habitat to optimize sampling of Pacific sardine (*Sardinops sagax*)

Juan P. Zwolinski, Robert L. Emmett, and David A. D—

Prediction and confirmation of seasonal migration of Pacific sardine (*Sardinops sagax*) in the California Current Ecosystem

David A. Demer (contact author)
Juan P. Zwolinski
Kyle A. Byers
George R. Cutter
Josiah S. Renfree

A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock

Distributions and abundances of Pacific sardine (*Sardinops sagax*) and other pelagic fishes in the California Current Ecosystem during spring 2006, 2008, and 2010, estimated from acoustic–trawl surve—

Juan P. Zwolinski (contact author)
David A. Demer
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George R. Cutter
Josiah S. Renfree
Thomas S. Sessions
Beverly J. Macewicz

ICES Journal of Marine Science

Sampling selectivity in acoustic-trawl surveys of Pacific sardine (*Sardinops sagax*) biomass and length distribution

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ATM Strengths

"One of the most urgent needs … is in our capability to make timely, synoptic, species specific stock assessments over wide geographic areas…underwater acoustics [is] the only recourse in conducting more than a surface examination of marine fish resources."

- D.V. Holliday, 1972

"… acoustic-midwater trawl surveys are the most effective means for directly assessing the status of northern anchovies [including] …distribution and abundance... availability, seasonal movements, schooling behavior, and vulnerability to harvest methods…"

- K. F. Mais, 1974

• Direct estimates for multiple species of fish and zooplankton

J.P. Zwolinski and D.A. Demer, 2012, "A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock," *Proceedings of the National Academy of Sciences* 109(11): 4175-4180.
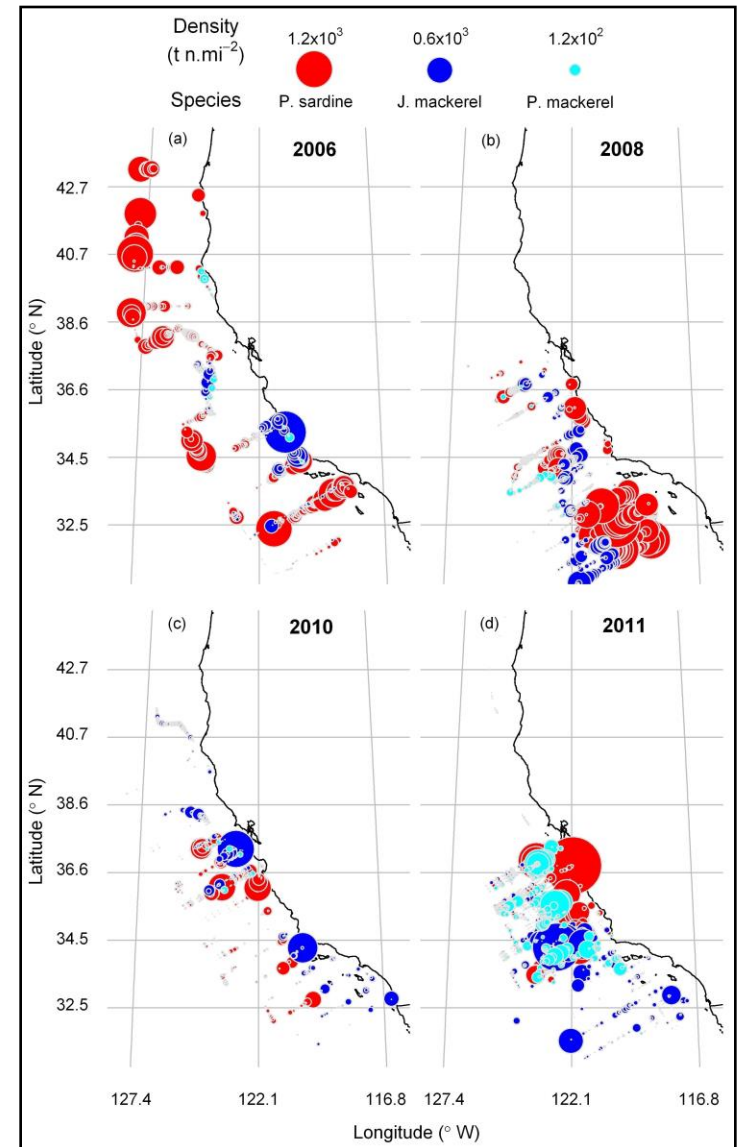
ATM – Challenges

- Sample Entire Stocks
- Sample Near Shore
  - Currently > 40 m seabed depth and 2 km from shore
- Sample Near Sea-Surface
  - Currently > 10 m water depth
- Better Estimate Species Proportions and Fish Sizes
  - Currently 1-3 nighttime trawls in areas with daytime CPS echoes
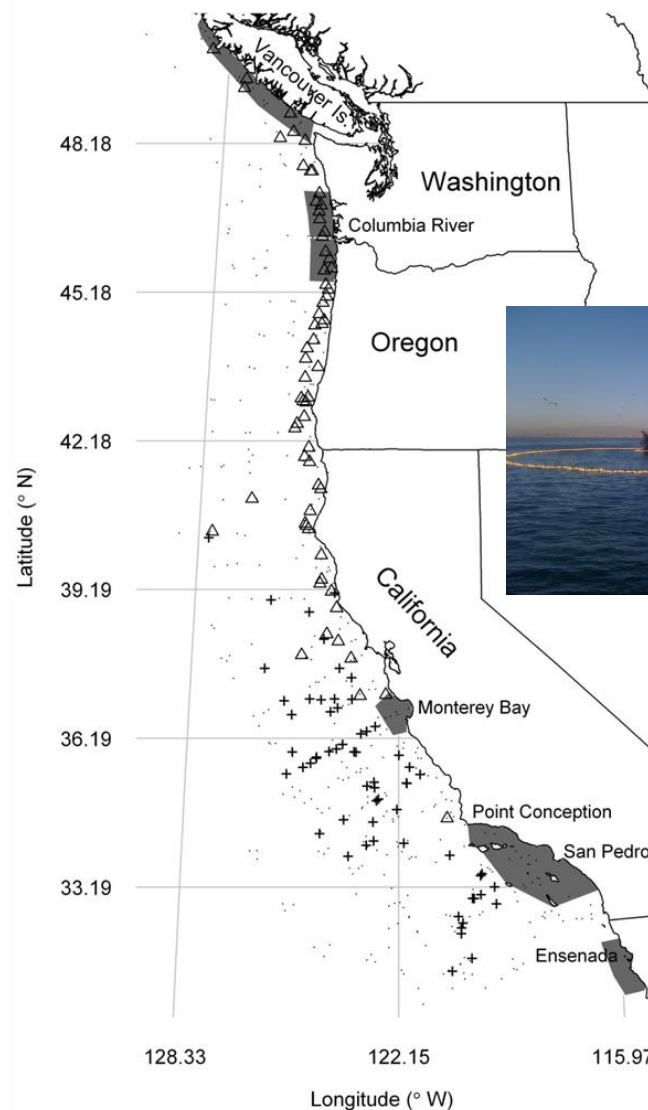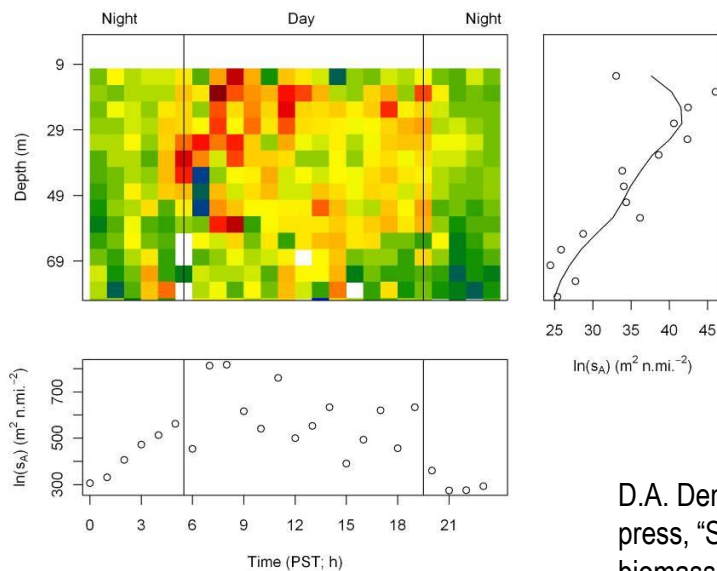
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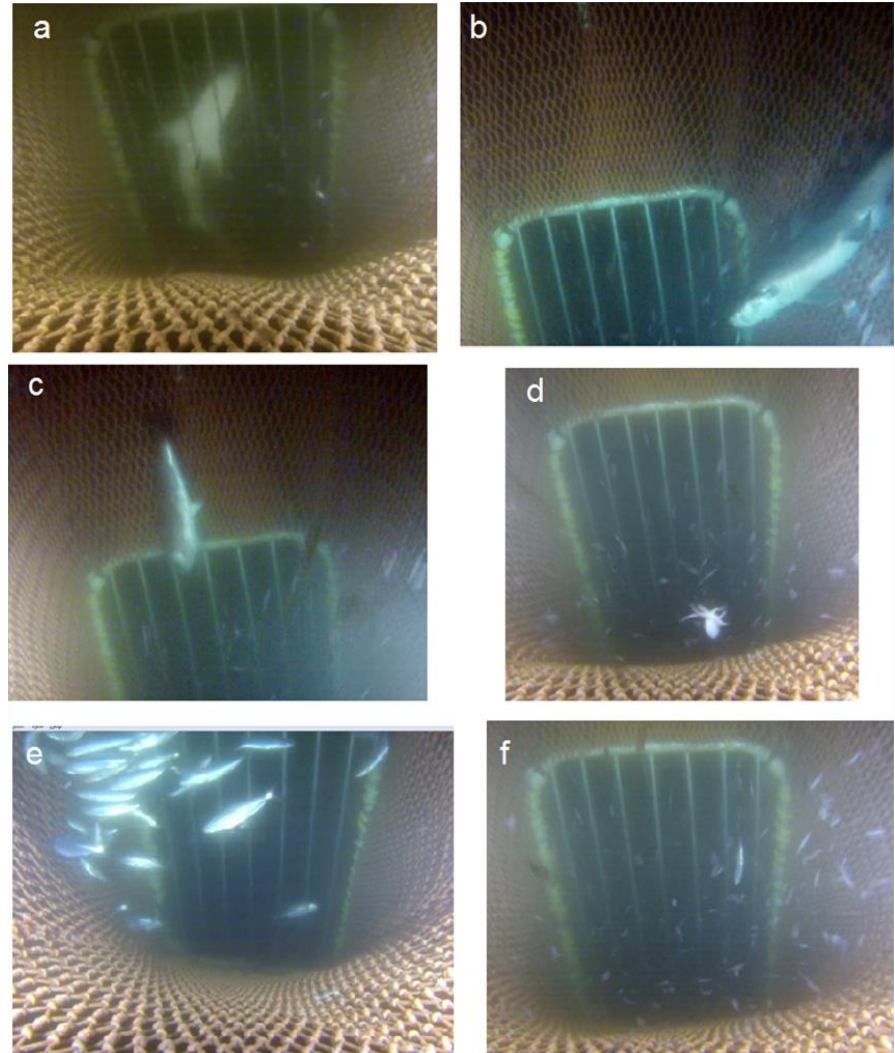# ATM Strategies for Improvement – Habitat Characterization

- Seasonal dynamics of the potential habitat for the northern stock of sardine
- Temperature regimes for the northern and southern stocks of sardine
- Apportion landings to different stocks
- Cooperatively sample transboundary stocks

D.A. Demer and J.P. Zwolinski, in press, "Corroboration and refinement of a method to differentiate landings from two stocks of Pacific sardine (*Sardinops sagax*) in the California Current," *ICES Journal of Marine Science.*
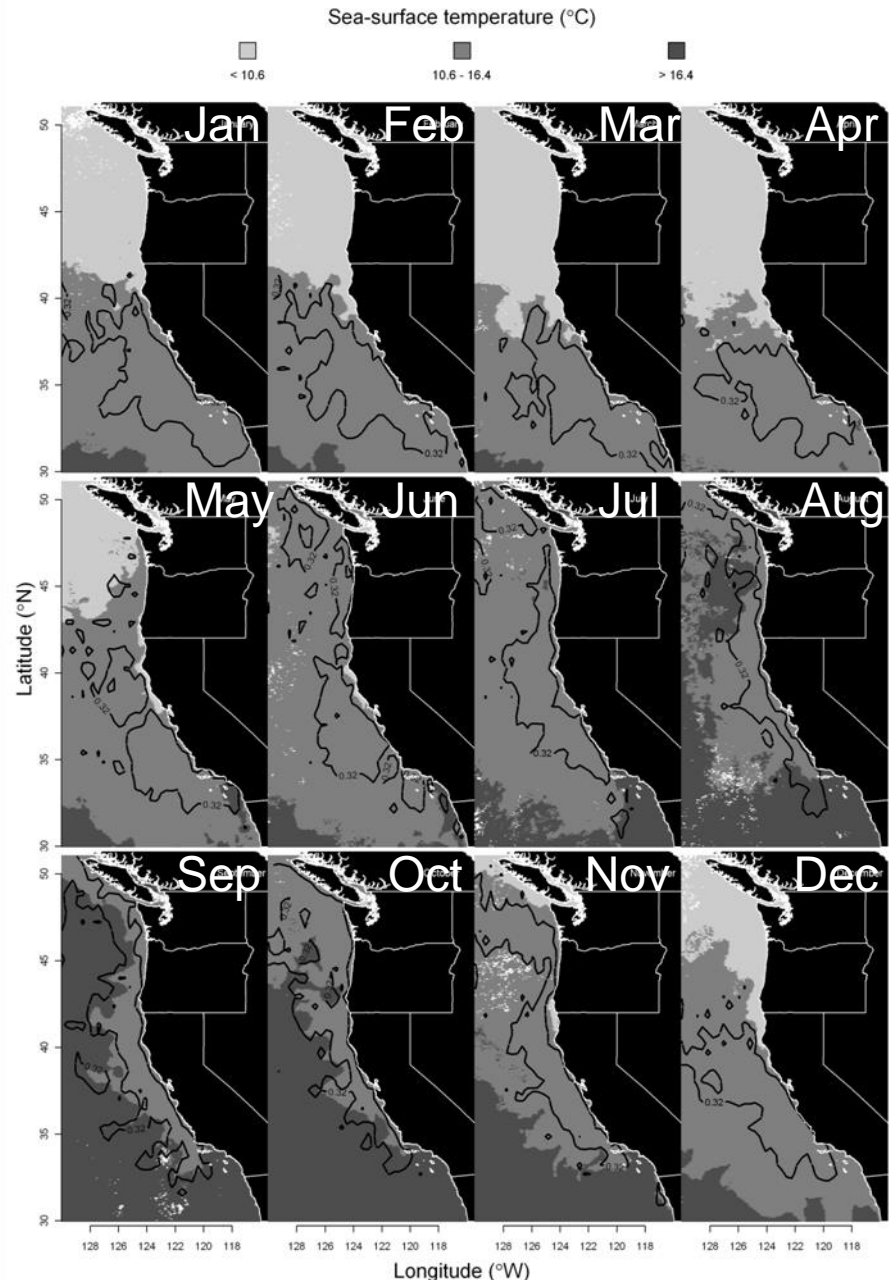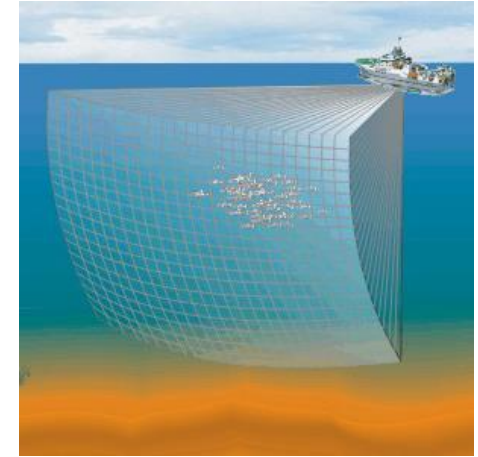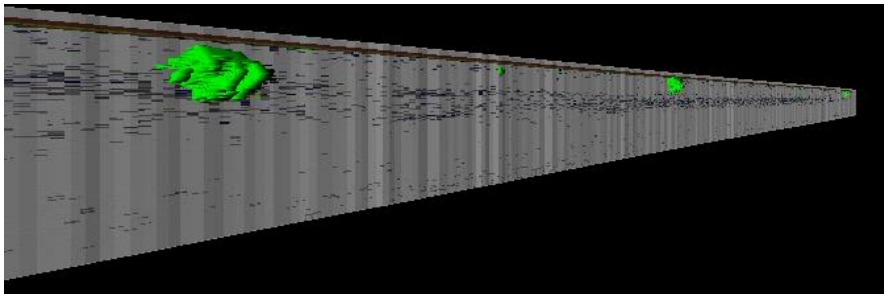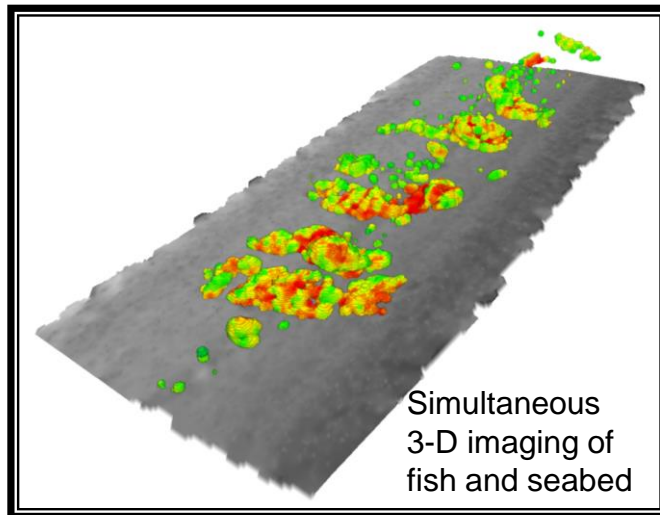
ATM Strategies for Improvement – Optical Sampling

- Monitor Trawl Performance
    - Trawl-mounted cameras
    - Monitor trawl shape and function
    - Observe fish behaviors
    - Quantify size selectivity
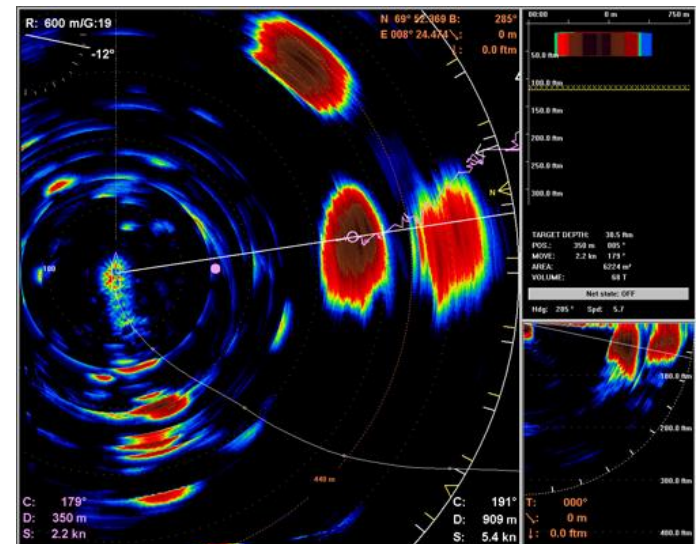- Sample optically underway

ATM Strategies for Improvement – Acoustic Imaging
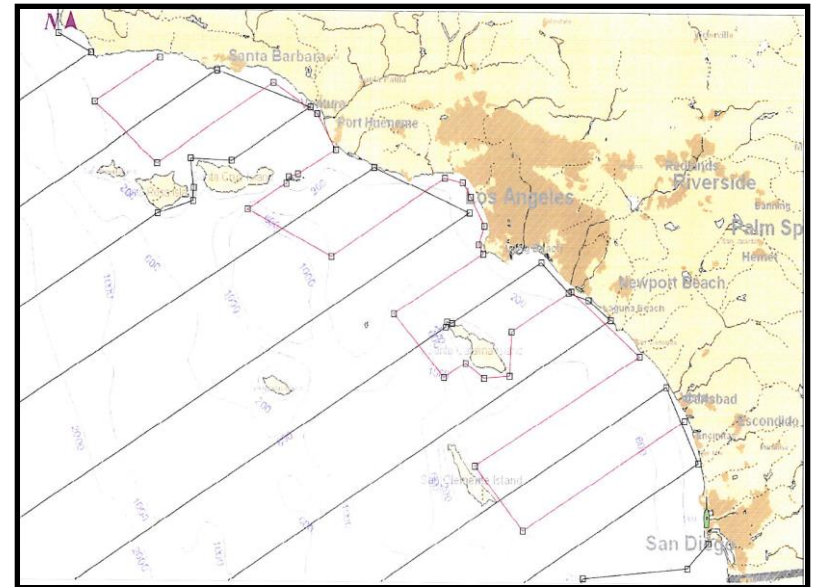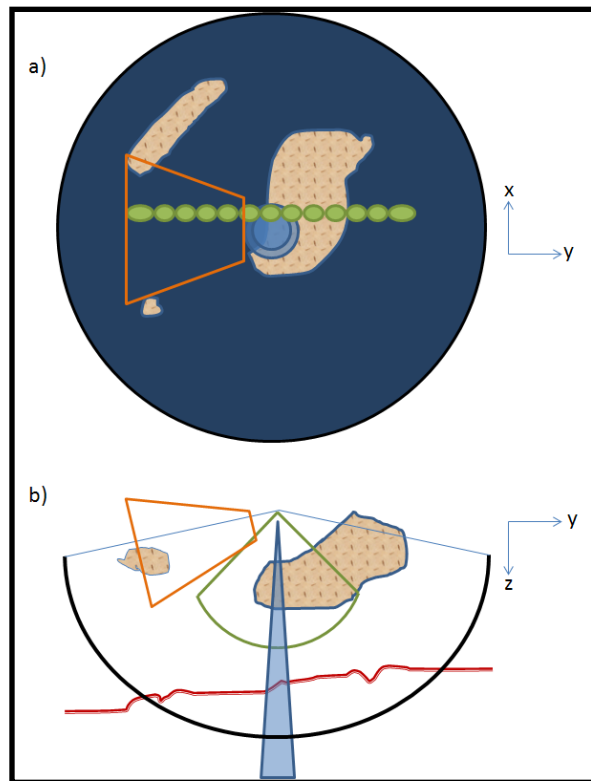
- Use Scanning, Multi-beam and Imaging Sonars

Simrad

Simultaneous
3-D imaging of
fish and seabed

ATM Strategies for Improvement – Automation and Enhanced Nearshore Sampling

Automate data collection, archive, processing, reporting, and dissemination

Increase ATM sampling nearshore, particularly in fishing regions